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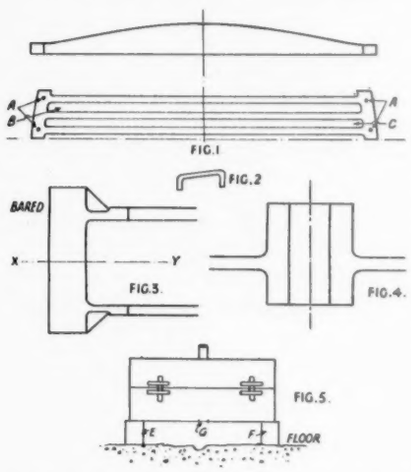
Cupola Theory

As a preliminary to a prolonged research upon cupola melting to be undertaken by the American Foundrymen's Association, Mr. G. S. Massari and his colleagues have translated and simplified a representative selection of theoretical Papers of Continental origin, germane to the subject. Obviously such action was desirable, for a full knowledge of the mechanism of combustion might lead to radical modification of furnace design. Personally, we have never been impressed with either the fundamental character of much of the Continental research work or its usefulness in practice. The former is scouted owing to the difficulty in obtaining satisfactory gas samples, and the variables to be associated with the raw materials, including atmosphere. The broad generalisations of Belden or Girardet (whose work was not included in Massari's thesis) which postulate the formation of zones will probably serve the practician to better purpose than the more theoretical concepts. The possible chemical and physical reactions between excess air and an incandescent column of coke carrying a ferrous burden, and fluxes—there being present both pressure and temperature gradients—are too complex to admit of simple mathematical treatment. Moreover, any attempt to vary one factor at a time will be elusive under anything but strictly laboratory conditions. However, we can rely on the American technicians to tackle their unquestionably difficult proposition on lines which will be productive of results utilisable in actual practice. So far as the applicability of German research work on cupola melting is concerned, we cannot say that we have noticed that in their works they operate any more efficiently than in Great Britain. Our methods have been conceded by German experts to be of a particularly high order, due, they say, to the better quality of coke normally used. We have also never been greatly impressed by claims of very low coke consumption, for thereby the efficiency of a cupola is not to be judged. We would not even rate it as the most important factor, preferring to postulate the percentage of good castings "over the scales," as they say in Lancashire. Obviously, it is important, but so too are the factors of the cost of relining the body of the furnace and the daily patching. When looking for economy in foundry practice, it is as well to reflect upon other types of melting furnaces, and therefrom draw some reasonable conclusions. For instance, it is apparent that the efficiency of most furnaces is more pronounced with increasing capacity, due to the decreasing ratio of fabric to metallic charge. Thus there is a minimum commercially economic capacity for most types of melting furnaces. The capacities of cupolas in this country probably range from the modest cupolette to an output exceeding 15 tons an hour. Yet there enters into the question the period of production, for this is the deciding factor as to whether or not a hot blast installation is worth while. If a relatively small cupola could work for really prolonged periods, then a regenerative system would be valuable. It resolves itself into a survey of the heat units and the time required for raising the temperature of the "gadget" which may take numerous forms, to a level where it becomes effective in giving out heat for properly preheating the blast. Thus time and mass are the determining factors in estimating whether a hot-blast system is worth while economically, and time, incidentally, is a dual concept, that of the duration of the blow and the period requisite for the proper functioning of any preheating arrangements. Such a study would have saved many headaches, when efforts were made a decade or so ago to introduce the hot-blast system into this country. In America, at the Griffin Wheel Company, the hot-blast system is a really practical proposition, because of the high output associated with the length of the blow. By cutting down the mass of the preheating mechanism, a system under consideration by one of our most prominent foundry managers, and of which we have had the privilege of examining the drawings, bids fair to bring the hot-blast system well within the range of most of the plants installed in this country. We look to the citation of the fundamentals of the hot-blast system as being one of the outcomes of the five-year research sponsored by the A.F.A.

Some Jobbing Foundry Experiences—XXV

By "TRAMP"

The art of densening by the application of either external or internal chills is becoming increasingly useful in foundries called upon to produce castings of complicated form and varying metal thickness. The jobbing founder, although not always so well versed in the art of "progressive solidification" as practised by more specialised foundries, nevertheless often unconsciously makes use of similar expedients but of cruder form. Recently the writer observed in a small jobbing shop a set of fire-bar sections for a vertical boiler, of which Fig. 1. is typical. These exhibited two pieces of cast iron bar at each end, as AA (Fig. 1). When questioned as to the purpose of these the founder explained that he had experienced considerable trouble with these castings cracking at BB or CC, in-



variably at the runner end, and that the insertion of a piece of ¼-in. diameter rod as Fig. 2 prevented this occurring. The practice of baring a portion of a casting to hasten its cooling is often resorted to in jobbing shops. Such a case is that of a heavy boss of a fairly light belt pulley with curved arms, while another example is shown in Fig. 3, which shows a section of a box-type casting jointed along XY, the interior being cored. Fig. 4 shows a heavy boss which was required very hard in the bore. To accomplish this it was necessary to chill the bore. A solid bar would be very difficult to remove because of the contraction on to it. The jobbing founder overcame this difficulty by placing an oil sand core in a core print in the usual way, but with this difference that the core was continued through the top box as Fig. 5. Also, the moulding box was placed on stands as EF (Fig. 5). The job being poured, the core was removed and a hole knocked through the bottom moulding box at G. A jet of water was then directed through the space previously occupied by the core and flowed away through a suitable channel. This water rapidly removed the heat from the bore, and consequently chilled the surface, making it hard as desired.

Finishing of Zinc Alloy Die Castings

In the use of any metal, consideration of the need for finishing is based on (1) the desire for decorative effects not obtainable in the metal itself, (2) the need for improved wear and abrasion resistance, and (3) the need for protection against special types of corrosive attack, stated E. A. Anderson in a Paper read at the recent meeting of the A.S.T.M. The author discussed these three main points in regard to methods used with zinc alloy die castings.

Catalogues Received

Foundry Lighting. A folder received from the British Thomson-Houston Company, Limited, of Crown House, Aldwych, London, W.C.2, is specially addressed to foundry executives and it sets out in plain English just what advantages can be anticipated from the installation of a properly balanced lighting system. Increased and better production is naturally emphasised, but some stress is laid on the effect that good lighting has upon entrants to the industry. It is certainly worth while writing to Crown House for a copy, as it will help the executive to marshall his arguments for better lighting with the powers that be.

Crucible Melting Furnaces. An extremely interesting three-page folder has been received from Midland Monolithic Furnace Lining Company, Limited, of Black Seam House, Narborough, Leicester. It describes a new system of crucible melting furnaces ranging from 120-lbs. to 1-ton capacity, the larger ones, of course, being made to tilt. Castings are incorporated for both the body, and the preheater, and thermal efficiency is ensured by proper insulation and the intelligent introduction of the air under pressure for combustion by preheating. Taking the 240-lb. (brass) capacity furnace, a claim is made to melt this quantity of 88:10:2 metal in 20 minutes, using either hard Durham or Welsh coke as fuel and to do this with a consumption of 25 lbs. of coke for the complete melt. As a fuel, coke offers many advantages under present conditions.

High Duty Castings. Ealing Park Foundry, Limited, Junction Road, South Ealing, London, W.5, have prepared an excellent 12-page catalogue outlining the potentials of Meehanite and the castings they supply made through using the processes essential for its manufacture. Thus the first two pages tell of the metal itself and thereafter examples are drawn from practice with suitable illustrations. A start is made with machine tools, and this is followed by examples from prime mover castings such as cylinders, crankshafts and camshafts. Here the sequence is interrupted to show in tabular form the physical properties of Meehanite and the British Standards Institution specifications for cast iron. This is done, not with the object of "showing how clever we are," but to indicate which grade of Meehanite is to be chosen for meeting the conditions imposed. The text then resumes its former character and describes and illustrates castings for press tools and dies, for compressors and other pressure resisting components —an interesting example cited being an air cylinder in the motor control gear for the latest L.P.T.B. underground trains. Once more the text reverts to the actual metal, and discusses the important aspect of the production of special properties through heat-treatment. Finally, as examples of this work, moulds for light alloy die castings and a burner tuyere assembly are illustrated.

Notes from the Branches

The *East Anglian Section* of the Institute of British Foundrymen has formed an advisory committee to co-ordinate local technical educational activities in so far as they affect the foundry industry. It also hopes to inaugurate a system of inter-works visits by foundry and patternshop apprentices. Mr. H. H. Shepherd is the chairman and Mr. J. L. Francis the honorary secretary. The next meeting of the Section is to be held at 3.30 p.m. at the Central Library, Ipswich, on September 20, when Mr. D. Carrick, of Crane, Limited, is to read a Paper on "Economy and Salvage in the Foundry."

Random Shots

It was interesting to learn in a recent Saturday night broadcast from America that the House of Representatives is based on true Yorkshire traditions. Yorkshire is the only county over here in which a man must be "born to the soil" in order to qualify for the county cricket team, whilst in the States a member of the House of Representatives must be a native of the district which he represents. There is no such thing as a "residential qualification." Yet, despite the obvious disadvantages in the political field, Yorkshire usually manages to put a "champion" team into the cricket field.

* * *

A harassed foundryman, who is working hard from dawn till dusk, writes asking the Editor to insert the following advertisement in the Agony Column:

"Wanted, Hairdresser. One with knowledge of manganese steel preferred."

It is felt, however, that the problem will eventually solve itself; for if he continues to work at such a pace that he can't stop to get his hair cut, he'll soon have no hair left to require cutting.

* * *

The perplexing plight of this correspondent reminds "Marksman" of a similar complaint made by his tailor in the halcyon days at the beginning of the war, when one ordered as many suits as one could afford "just in case." The fitting room of the shop was crowded with half-made suits, which were festooned four deep around the walls. "Those suits," complained the tailor, bitterly, "belong to customers working so late that they cannot come in for fitting. Some have been there for nearly three months." He was probably afraid lest his customers should work late once too often and need a shroud instead of a suit.

* * *

In these difficult times it may be hard for the bread-winner to make both ends meet, but it is infinitely harder for the bread-eater to make both ends meat.

* * *

£1,747 4s. per annum for Diggings!

A lady in a provincial town is advertising for a family of four as paying guests at eight guineas each per week. Poor Farver!

"MARKSMAN."

Institute of British Foundrymen

THE NEW BRANCH PRESIDENTS

The following is a list of the presidents of the various branches and sections of the Institute of British Foundrymen for the current session:—

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Reports on Special-Duty Cast Irons

II—AUSTENITIC CAST IRONS*

By J. G. PEARCE, M.Sc., M.I.Mech.E. (Director, British Cast Iron Research Association)

Austenitic cast irons may be regarded as bearing the same relation to ordinary cast irons as some of the stainless steels bear to the ordinary steels. Although more expensive, both in raw materials and manufacture, the austenitic cast irons have properties which mark them off as different from all other cast irons, particularly in their softness and ductility; high resistance to wear, erosion, corrosion and heat; non-magnetism and relatively high electrical resistance; low thermal conductivity and high thermal expansion. Their mechanical properties compare with those of a good engineering cast iron, but their softness and toughness make them readily machinable. They are readily welded. They are not susceptible to ordinary heat-treatment, i.e., *quenching and tempering, but nevertheless can be annealed at low temperatures with advantage. They can be cast white if required, and a simple thermal treatment such as annealing at 950 deg. C. for 30 minutes yields a metal with 2 to 3 per cent. elongation in the cold. While the founding of these irons presents special problems, these can be overcome and the smallest castings can be, and are, successfully made in austenitic irons, down to ¼-in. section; but if thin sections should be hard, they can be softened by the treatment given above. They melt at about 1,150 deg. C., a figure similar to that of the non-phosphoric cast irons, and have a specific gravity of 7.2 to 7.6.*

The present Paper is intended primarily as a guide to the engineering properties of the austenitic cast irons, in order that engineers may use them to the fullest extent justified by their properties. The data presented are drawn from authoritative sources, and a list of the Papers and reports consulted is given at the end. In general, the data are those of interest to the user rather than the maker, to the engineer rather than the metallurgist.

As indicated in the scheme of classification outlined in the Report on Austenitic and Martensitic Cast Irons, austenitic cast irons are those in which the predominating constituent is austenite, the remaining constituent being graphite, except when the austenite-cementite eutectic fails to decompose to austenite and graphite, in which case they need the softening treatment mentioned above. They can be made by the addition of certain alloys, in defined amounts, to cast irons. Of these additions, nickel is the most important, and is the only one, so far as is now known, alone capable of rendering an iron austenitic without at the same time increasing the carbide content and hence giving an undesirably high proportion of eutectic in the structure. Cast irons of about 3.5 per cent. carbon and over 1 per cent. silicon become fully austenitic with an addition of 20 per cent. or more of nickel. The addition of certain other elements enables desired modifications of properties to be made, or, alternatively, the amount of nickel to be reduced. Thus copper can be used to some extent to replace nickel, and chromium is a convenient means of increasing both the hardness and heat resistance. Irons can be made austenitic by the use of manganese (only half as much manganese as nickel being required), but only at the expense of an undesirably high proportion of carbide. A manganese-silicon-aluminium austenitic iron has been described, of total carbon 3.5 per cent., silicon 3 per cent., manganese 9 per cent., and aluminium 3 per cent., but is not in commercial use. Although relatively non-magnetic, it is less machinable than other austenitic irons, and becomes magnetic again at temperatures round about 400 deg. C. The maximum manganese content for austenitic irons in commercial use is about 5 per cent., but even these are of inferior resistance to corrosion.

Certain special austenitic irons containing over 30 per cent. nickel—such as a 40 per cent. nickel, 15 per cent. chromium iron—are made for applications where low thermal expansions are necessary, and for certain chemical purposes. Although the thermal expansion of the more usual austenitic irons is high, it falls with further increase in the nickel content, and at 33 to 36 per cent. nickel, expansions comparable with those of invar are obtained, the minimum being six parts in a million per degree centigrade.

In general, properties will be discussed in relation to those well-established types of austenitic cast iron, on which most of the work available has been done. These are known as "Nomag" (Dawson, 1924, for Ferranti);† "Ni-resist" (Merica 1930, for the International Nickel Company, and Arnott for G. and J. Weir, the metal being originally called "Nimol"); and "Nicrosilal" (Norbury and Morgan 1933, for the British Cast Iron Research Association).

Commercial Austenitic Cast Irons

Nomag, introduced primarily as a non-magnetic iron, normally contains 10 per cent. nickel and 5 per cent. manganese. Ni-resist is a nickel-copper-chromium iron, introduced primarily as a corrosion-resisting iron, but generally useful wherever austenitic irons are suitable, and the normal composition is 14 per cent. nickel, 7 per cent. copper and 2 per cent. chromium. Nicrosilal is a nickel-chromium-silicon iron, introduced primarily as a heat-resisting iron, but also generally useful. The normal composition is:—Nickel, 18 per cent.; chromium, 2 per cent.; and silicon, 5 per cent. Wide variations in these compositions can be made to suit special requirements.

More particularly, the range of, and recommended percentage compositions for, Ni-resist and Nicrosilal are given in Table I, and it is for such compositions that most of the data on properties are available:—

TABLE I.—*Composition of Ni-Resist and Nicrosilal.*

	Ni-resist.		Nicrosilal.	
	Range.	Recommended.	Range	Recommended.
Total carbon ..	2.7–3.2	3.0	1.8–2.0	2.0
Silicon ..	1.0–2.0	1.5	5.0–7.0	5.0
Manganese ..	0.8–1.5	1.0	0.5–1.0	1.0
Sulphur ..	Nil–0.12	0.1	Nil–0.12	0.1
Phosphorus ..	Nil–0.40	0.2	Nil–0.2	0.1
Nickel	12.0–16.0	14.0	16.0–20.0	18.0
Copper ..	6.0–8.0	7.0	—	—
Chromium ..	1.5–4.0	2.0	1.8–5.0	2.0

The figures quoted for Ni-resist apply to sections of 0.25 in. to 1 in., and for larger sections the nickel should be increased by 2 to 3 per cent. For alloys in contact with foodstuffs the copper should be replaced by its equivalent of nickel. The low carbon content of Nicrosilal is brought about by the high silicon content; and even melting in a cupola will not normally yield a higher carbon. Limits to composition are set by the necessity for avoiding any transformation, wholly or in part, of austenite to martensite, which causes an increase in hardness and volume, and restoration of magnetic properties. In the case of Nicrosilal intended for temperatures of 500 to 700 deg. C., the silicon content should be below 5 per cent. (*i.e.*, 4.0 to 4.5 per cent.) and the nickel not below 17 per cent. (*i.e.*, 18 to 20 per cent.).

MECHANICAL PROPERTIES

The mechanical properties include transverse strength and deflection; tensile strength and elongation; elastic modulus; impact and shock strength; fatigue strength; creep strength; hardness; strength and rigidity at elevated temperature.

Static Properties

Unless otherwise stated, the transverse and tensile strengths are measured in tons per square inch, and deflection in inches, in accordance with British Standard Specifications No. 321 (1938) and No. 786 (1938). Brinell figures are given in the normal manner at 3,000 kg. with a 100-mm. ball for 30 secs.

The range of mechanical properties for Ni-resist irons is:—

Ultimate tensile stress, tons per sq. in.	9.0 to 15.5
Transverse rupture stress, tons per sq. in.	19.6 to 31.5
Deflection (18-in. span), inches ..	0.2 to 0.7
Brinell hardness number	120 to 170

A plain engineering iron of 14 tons per sq. in. tensile strength has a deflection of 0.2 in. or less under the same conditions.

The hardness of chromium-free compositions is about 100 on the Brinell scale, and this is increased by about 20 points for each 1 per cent. of chromium added; say 220 at 6 per cent. chromium. Chilling in the mould yields hardness values of 350 to 400.

The range of mechanical properties of the Nicrosilal irons is:—

Ultimate tensile stress, tons per sq. in.	8 to 20
Elongation on 2 in., per cent. ..	1 to 4.5
Transverse rupture stress, tons per sq. in.	22 to 41
Deflection, inches	0.7 to 1.4
Brinell hardness number	110 to 170

Bars cast mottled or white and softened by annealing at 950 deg. C. gave bend values varying from 44 deg. for a 0.325-in. bar to 60 deg. for a 0.25-in. bar. Bars cast grey gave bend values, tested in the cold in the as-cast state, varying from 7 deg. for a 0.875-in. bar to 27 deg. for a 0.325-in. bar.

Tests have been reported on Ni-resist with varying amounts of chromium outside the usual range, the Brinell hardness numbers varying from 149 to 241. These tests were made on centrifugally cast material, on ring specimens, and a measure of permanent set was obtained for gapped rings by applying a definite stress and measuring the change in the gap after removal of the stress. The value decreased with increase of chromium, and thermal treatment decreased the set of the low chromium and increased that of the high chromium alloys. Even after the heat-treatment, the permanent-set values of austenitic cast irons were approximately of the same order of magnitude as those of various non-ferrous alloys, bronze and aluminium. The elastic modulus values, as determined from the ring test, are also given (13.6 to 21.0 million lbs. per sq. in.). In an earlier account of these same experiments, it is stated

* Prepared for the Research Committee of the Institution of Mechanical Engineers on High-Duty Cast Irons for General Engineering Purposes, by the reporter, J. G. Pearce, M.Sc., M.I.Mech.E, and reproduced by kind permission of the Institution.

† See bibliographical references at the end of the Paper.

Special-Duty Cast Irons—II

that at 7 per cent. chromium content, the irons of the Ni-resist type become unmachinable, but the strength properties are satisfactory up to 4.2 per cent. chromium.

Little information is available on resistance to shock; and on account of variations in test-pieces and procedures, figures should be taken only for the sake of the comparison with grey iron. A single-blow test of the Charpy type gave 117 ft.-lbs. for Ni-resist, compared with 43 ft.-lbs. as an average for ten pearlitic irons. Corresponding figures for an Izod type test were 98 and 36 ft.-lbs. Other Izod tests have shown a ratio of austenitic to pearlitic iron of 8/1 in shock strength.

Izod impact tests on cast iron taken on an unnotched round bar 0.798 in. dia., machined from a standard bar, gave the following figures: Common irons, 4 to 6 ft.-lbs. on the standard machine; high-duty irons, 8 to 10 ft.-lbs.; ladle-treated irons, 12 to 18 ft.-lbs. (having ultimate tensile stresses of 20 to 25 tons per sq. in.); and austenitic cast irons, 15 to 35 ft.-lbs. impact.

Elastic Modulus

The figure for Young's Modulus is difficult to apply to cast metals which show slight plastic deflection at low loads, but at loads within the working range there is an approximately linear relation between load and deflection, or load and elongation. While in ordinary cast irons the elastic modulus so obtained may be regarded as 10 to 23 × 10^6 lbs per sq. in., according to tensile strength, and approximately in proportion thereto, the austenitic irons gave a range of 14 to 21 × 10^6 lbs. per sq. in.

Fatigue Strength

The endurance limit of engineering cast iron is approximately one-half the ultimate tensile strength. A series of austenitic cast irons having ultimate tensile stresses of 13 to 17 tons per sq. in. and transverse rupture stresses of 25 to 30 tons per sq. in., gave fatigue strength values in bending of ± 6 to ± 9 tons per sq. in.

Properties at Elevated Temperatures

Ordinary engineering irons tend to become plastic at high temperatures; while hard irons, rigid or brittle at ordinary temperatures, remain relatively rigid at elevated temperatures. Austenitic irons, in spite of their softness at ordinary temperatures, remain rigid at elevated temperatures. Tests in which the metal was progressively loaded and tested as a cantilever at 850 deg. C. showed that an ordinary engineering iron deflected 1 in. at a stress of 0.6 ton per sq. in., and steels showed the same deflection at 0.5 to 0.6 ton per sq. in. Austenitic irons gave a deflection of 1 in. at stresses of 1.4 to 2.2 tons per sq. in., the latter figure corresponding to high chromium contents and the former to normal compositions.

Tests on ordinary cast irons and Ni-resist were made, in which the samples were raised to 450 deg. C. for 47 days and then to 600 deg. C. for 30 days. The ordinary cast iron dropped in tensile strength from 14 to 9 tons per sq. in., and the Ni-resist was unaffected at 15 tons per sq. in. after the treatment.

Good engineering irons maintain their mechanical properties without appreciable change up to about 450 deg. C. Tests carried out at elevated temperatures on a sample of a hard Nicrosilal of 4.3 per cent. chromium gave the following results, the load being applied at the rate of 44 lbs. per min.:—

At air temperature:—	
Ultimate tensile stress, tons per sq. in. ..	9.2
Elongation on 2 in., per cent.	Nil
At 800 deg. C.:—	
Ultimate tensile stress, tons per sq. in. ..	3.45
Elongation on 2 in. per cent.	3

Ni-resist and Nicrosilal irons tested at the National Physical Laboratory gave the following results:—

	Ni-resist.	Nicrosilal.
At air temperature:—		
Transverse rupture stress, tons per sq. in.	22.6	24
Deflection, inches	0.19	0.5
Elongation, per cent. ..	0.5	1.5
Ultimate tensile stress, tons per sq. in.	11.3	11.2
At 450 deg. C.:—		
Ultimate tensile stress, tons per sq. in.	10.2	8.3
At 538 deg. C.:—		
Ultimate tensile stress, tons per sq. in.	9.6	7.7

The investigators concluded that, at the elevated temperature for which Nicrosilal is designed (850 deg. C.), Nicrosilal is superior to Ni-resist in resistance to creep, but that at lower temperatures (450 deg. C. and 538 deg. C.) Ni-resist has good growth and creep properties, and its austenite is more stable than that of Nicrosilal.

The limiting creep stress in tons per sq. in., *i.e.*, the stress producing within 30 to 40 days a creep rate of 10^{-7} in. per inch per day, was as follows:—

	At 450 deg. C.	At 538 deg. C.
Ni-resist, tons per sq. in. ..	4	2
Nicrosilal, tons per sq. in. ..	3	1

Figures reported from U.S.A. on a Ni-resist type of iron of 3.3 per cent. chromium, and a Brinell hardness of 195 to 215, are set out in Table II.

TABLE II.—*Creep Strength of Ni-resist Type Iron at Elevated Temperatures.*

Stress, tons per sq. in.	Rate of creep per 1,000 hours.	
	At 450 deg. C., per cent.	At 1,000 deg. C., per cent.
2.0	—	0.013
3.0	—	0.021
4.0	0.045	0.10
4.9	—	0.34
6.0	0.09	0.96
7.15	—	2.5
8.0	0.19	—

Erosion-, Abrasion- and Wear-Resistance

In spite of their softness, austenitic cast irons are highly resistant to wear. In the U.S.A., Amsler wear tests of the brake shoe type showed that Ni-resist has a resistance to wear of over four times that of plain cast iron under the same conditions.

In automobile engine practice, a commercial vehicle which averaged a maximum cylinder bore wear of 0.006 in. per 1,000 miles on sand-cast liners, had this wear reduced to one-third by the use of hardened and tempered pearlitic cast iron, and to about one-twelfth by the use of austenitic cast-iron liners.

The work of the Institution of Automobile Engineers has shown that the wear in a cylinder is in part due to abrasion and in part due to corrosion. The latter predominates on starting, and in engines frequently stopped and restarted. It is due to water condensation from the fuel, on the cold cylinder wall, forming acids. The use of a corrosion-resisting austenitic cast iron naturally suggested itself, and the Institution of Automobile Engineers reports (1937) that Ni-resist has since become widely used and is considered to be amongst the best materials available for conditions involving intermittent operation. One maker stated that under certain conditions of service, austenitic cast-iron liners have enabled wear figures to be improved from 0.001 in. per 250 to 500 miles to 0.001 in. per 2,000 to 4,000 miles. Such liners have also been used successfully under conditions where abrasion probably predominates, and an omnibus-operating company reported a wear of 0.001 in. per 2,200 miles for ordinary unhardened cast iron liners, and a wear of 0.001 in. per 5,500 miles for austenitic liners. Another company reported a wear on austenitic liners of 0.001 in. per 8,160 miles.

Investigation was made by the Institution of Automobile Engineers on cylinder wear, on a stationary engine running under two clearly defined sets of conditions described as moderate and severe respectively, and maintained constant for each liner, which was tested first under the former and then under the latter conditions. Plain cast iron gave a wear figure of 0.0013 in. per 1,000 miles under the moderate, and 0.0043 in. per 1,000 miles under the severe conditions. In the ordinary way the latter high figure is only reached in certain delivery service vehicles. Under the moderate conditions, the austenitic liners gave a wear figure of approximately 0.00025 in. per 1,000 miles, and under severe conditions, 0.0004 in. per 1,000 miles, being five to ten times as good as plain cast iron and more wear-resisting than any other material tried except very high-chromium (32 per cent. chromium) cast iron and chromium-plated cast iron. Intrinsic hardness was stated to be comparatively unimportant in its influence on wear. The cylinder materials giving low cylinder wear also gave low piston ring wear.

A commercial vehicle working under conditions of a small daily mileage and many stops gave a wear of 0.006 in. per 1,000 miles with the original sand-cast liners, and 0.0005 in. per 1,000 miles for austenitic liners, the wear of hardened and tempered cast iron liners being between these figures.

An industrial firm estimates pump erosion by measuring the weight loss in 24 hours of a test disc of the material running at 3,000 r.p.m. in the fluid to be pumped. In mixtures respectively half and half of sand and water, coal dust and water, and clinker and water, the loss in weight on austenitic cast iron was 0.45, 0.21, and 0.45 of that on plain cast iron.

In a case of cavitation erosion, the relative rates for Ni-resist and ordinary cast iron were 109 and 636 respectively.

Machinability

Little information is recorded on the machinability and working properties of austenitic irons, but they are machined as readily as ordinary cast iron. This is borne out by their low Brinell hardness. Heavier cuts at slow speeds are preferable to light cuts at high speeds on account of possible surface work-hardening, which may also cause chips to become partially martensitic and hence partially magnetic. They take a very fine surface finish, in many cases a mirror finish, and the high resistance to atmospheric corrosion causes this to be retained for lengthy periods. The use of chromium contents above 3 per cent., however, increases the hardness on account of the presence of hard chromium carbide, and consequently the machinability in these cases is reduced.

If the structure is not fully austenitic on account of variations in composition, it may contain some martensite, which causes a higher hardness, and greater difficulty in machining.

Welding Properties

Austenitic cast irons are readily welded by rod of the same composition, by either electric or gas welding processes. Elements which cause difficulty in welding ordinary cast irons are present in much smaller amounts in austenitic irons; moreover the inherent resistance of the iron to oxidation and scaling, the absence of any volume change corresponding to the change

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in ordinary cast irons from austenite to pearlite on cooling, and the slight ductility of the metal, are properties which simplify welding considerably. The weld is soft and machinable.

Austenitic welding rod is so satisfactory that there is a tendency to use it on grey (pearlitic) iron welding, but the risk of hardness at a martensitic zone, where the pearlitic iron and austenitic zones meet, and where the austenitic composition is diluted, has to be guarded against. Photomicrographs of both gas and electric welds of grey iron and austenitic iron, using austenitic filler rod, have been published.

TABLE III.—*Average Loss in Weight of Cast Irons.*
The average loss in weight is given in grammes per square metre per hour.

	Sulphuric acid 2 normal.	Hydrochloric acid 2 normal.	Nitric acid 2 normal.
Grey cast iron (pearlitic, 0.5 per cent. P)	72.6	115.0	267.9
Austenitic iron (Ni-resist type, 1.4 per cent. Cr) ..	0.08	0.15	275.5
Austenitic iron (Ni-resist type, 3.2 per cent. Cr) ..	0.08	0.15	273.5
Pearlitic steel (1.09 per cent. C)	86.5	2.1	358.4
Stainless steel (0.8 per cent. C, 24 per cent. Ni, and 2.3 per cent. Cr) ..	0.10	0.15	390.0

Monel electrodes are also used satisfactorily for welding austenitic irons, especially for the electrical welding of Ni-resist.

Shrink Fitting

The temperature of the change in austenitic cast iron corresponding with the pearlite change in ordinary cast iron is below atmospheric temperature. A case is recorded in which liners were cooled in liquid oxygen to −183 deg. C. to obtain a shrink fit, but this was below the transformation temperature of the metal. A temperature not so low being required, solid carbon dioxide was successfully used; the liners were cooled to −79 deg. C.

Resistance to Corrosion

Considerable information is available on the corrosion resistance offered by austenitic cast

TABLE IV.—*Resistance of Cast Irons to Corrosion.*

	Sulphuric acid.	Hydrochloric acid.	Nitric acid.
Ordinary grey iron ..	328	301	218
Hematite	301	253	284
Ni-resist	2.8	1.5	214
Nicrosilal	1.5	1.5	163

irons compared with ordinary cast irons, but results often vary considerably with the conditions under which the test is made, temperature and concentration of the corroding medium, and erosion effects. The loss is not necessarily constant with time. The corrosion of austenitic irons may vary from 1/10 to 1/500 of that of ordinary cast iron under the same conditions.

Thus, after prolonged exposure to the atmosphere, the corrosion of plain cast iron was 10 times that of Ni-resist. In aerated tap-water the ratio was about 9/1, and in water at 95 deg. C. saturated with carbon dioxide, corresponding to bad boiler water, the ratio was 6/1. In various weak acids, the ratio was from 5/1 to 10/1, while in hot caustic soda the ratio was 14/1. In many instances the resistance of austenitic cast iron to corrosion is comparable with that of brasses and bronzes.

The resistance of Ni-resist to sulphurous gases is shown as follows. Ni-resist containing 3.5 per cent. chromium showed one-fifth of the corrosion of plain cast iron in hydrogen sulphide gas at 96 deg. C. In liquid salt at 815 deg. C. the corrosion of the austenitic iron was one-third, the scale formed one-tenth, during a period of 240 hours, and the growth after the same period about one-fifth of the corresponding values for plain cast iron. The corrosion ratios are based on loss of weight in milligrammes per square decimetre per day. Austenitic irons do not offer anything like the same corrosion resistance to nitric as to other mineral acids, but are at least as good as grey cast iron.

For detailed information on corrosion losses in a variety of media, the following references may be consulted: Coyle 1932-3; Hudson 1938; Mond Nickel Company 1933, 1937; Vanick and Merica 1930.

The comparative laboratory figures given in Table I are reported from France. The cast metals were all tested in the as-cast state, the pearlitic steel was annealed at 825 deg. C. and cooled in the furnace, and the stainless steel was quenched in water from 1,050 deg. C.

The austenitic steels and irons show a marked reduction in corrosion compared with pearlitic steels and irons, except in nitric acid, and both cast irons compare favourably with the corresponding steels. The necessity for employing nickel for austenitic structures instead of manganese, where resistance to corrosion is needed, was demonstrated by testing a manganese steel, which is austenitic (1.18 per cent. carbon and 15.3 per cent. manganese), after quenching. It lost 231 gm. per sq. metre per hr., while a nickel-chromium austenitic steel (as in Table I) lost 0.10 gm. per sq. metre per hr. in binormal sulphuric acid. Ni-resist type austenitic cast iron in the as-cast state lost 0.02 gm. per sq. metre per hr. in 5 per cent. sulphuric acid, but lost 11.0 gm. per sq. metre per hr. when annealed at 500 deg. C. for 320 hrs., which partially converted it to martensite. A lower nickel iron (7.8 per cent. nickel), more completely converted to martensite by the same annealing treatment, lost 72.01 gm. per sq. metre per hr.

The figures given in Table IV for resistance to corrosion show a similar trend, and represent the loss in weight per unit area in unit time on three mineral acids of normal (N) strength.

Resistance to Heat

Resistance to heat includes resistance to growth or change of dimensions on continuous heating or intermittent heating and cooling (which arises from internal oxidation), and resistance to scaling or external oxidation. Resistance to heat, like resistance to corrosion and wear, is not so much an intrinsic property of the material as a function of the external conditions—temperature, speed of heating, temperature gradient, and accompanying corrosive or erosive factors. Considerable data are, however, available.

Laboratory tests on resistance to growth and scaling at high temperatures in an oxidising gas such as moist carbon dioxide have shown that conditions which would cause an increase in volume of 30 per cent. in a good engineering iron, have shown a volume increase of 1.4 to 2 per cent. in soft, and 0.5 to 1.0 per cent. in hard (higher chromium) Nicrosilal. The weight increase in the soft grade was 0.2 per cent. and in the hard grade 0.04 to 0.1 per cent. Soft Nicrosilal increased 1 per cent. in volume after two heats in moist carbon dioxide at 1,000 deg. C. Comparative tests on bars of various materials in a gas muffle at 1,000 deg. C. showed that a soft grade of Nicrosilal was practically untarnished after the treatment and had a growth of 1.3 per cent., which was about one-fourth of the normal thermal expansion of the metal up to this temperature. A good engineering cast iron under the same conditions grew to the extent of 16 per cent.

Tests in the U.S.A. have shown that Ni-resist at 650 to 815 deg. C. has ten to twelve times the resistance to oxide formation of plain cast iron in oxidising atmospheres.

Tables V and VI give figures for tests from different sources.

An ordinary cast iron of 14 tons per sq. in. tensile strength was tested in superheated steam at 480 deg. C. with Ni-resist; and after 1,300 hours the ordinary iron had grown seven times more than the Ni-resist. After 240 hours at 750 deg. C., an ordinary cast iron lost 97 gm. in weight and Ni-resist 9 gm.

A large industrial firm tested soft and hard (higher-chromium) varieties of Nicrosilal along with two high-duty engineering irons, all made

TABLE V.—*Resistance of Various Cast Irons to Heat.*

	Temperature at which serious deterioration occurs (growth and scaling), deg. C.	Temperature at which appreciable scaling occurs, deg. C.	Recommended maximum for practical use, deg. C.
Ordinary cast iron ..	500	500	450
Pearlitic cast iron	650	500	550
1 per cent. chromium cast iron ..	750	550	600
Silal (4 to 10 per cent. Si)	900	800	750
Nicrosilal and similar high chromium and nickel-chromium cast irons	No change up to 1,000	900	950

by themselves. Under conditions causing the engineering irons to increase in volume 70 per cent. and 40 per cent. respectively, and in weight 21 per cent. and 11 per cent. respectively, soft Nicrosilal actually decreased 2.5 per cent. in volume and 5 per cent. in weight. Hard Nicrosilal increased 0.4 per cent. in volume and decreased 1.3 per cent. in weight. Slight non-adherent scale caused the loss in weight.

In a continuous tar-distillation still, three horizontal stills operate respectively at 220 deg. C., the second at 300 deg. C., and the third at 270 deg. C., with steam injection. Heavy corrosion was experienced on No. 2 still, and Nicrosilal gave three times the life of stainless

TABLE VI.—*Scaling Test.*

Temperature deg. C.	Mild Steel	Ni-resist	Silal.	Nicrosilal.
900	Scaled	No effect	No effect	No effect
950	—	No effect	Slight scaling	No effect
1,000	—	No effect	Bad scaling	No effect
1,050	—	Scaled	—	No effect
1,100	—	—	—	No effect
1,150	—	—	—	Scaled; started to melt
1,200	—	—	—	—

steel, without by any means reaching the end of its useful life. Mild steel gave only one-tenth of the life of stainless steel.

PHYSICAL PROPERTIES

Thermal Expansion

The thermal expansion of grey cast iron is constant from ordinary temperatures up to the temperature of the pearlitic change (about 760 deg. C.) except for a slight change at about 200 to 250 deg. C., which for engineering purposes is negligible. At the pearlitic change the material contracts as graphite is dissolved, and when this contraction is complete expansion continues at an increased rate compared with

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temperatures below the pearlite change. The value for temperatures up to 650 deg. C. is 14×10^{-6} and changes very little with composition.

For austenitic irons, which suffer no pearlite change, the expansion is constant up to 1,000 deg. C., and the value of the coefficient of expansion is 18×10^{-6}. This value is close to that of aluminium, which in some cases facilitates the use of ferrous and non-ferrous metals together. For reduced expansions, the nickel percentage can be increased; the tensile and transverse strengths are then lowered, the range of tensile strength of a 30 per cent. nickel, copper-free Ni-resist being about 7 to 11 tons per sq. in. The lowest expansion rates are found in irons of 34 to 35 per cent. nickel. Fuller details are given by Wood (1935). The replacement of all the copper in Ni-resist by nickel (giving 20 per cent. nickel) gives only a slightly lower value for the thermal expansion; but increasing the nickel to 35 per cent. gradually reduces the expansion to about 6×10^{-6}.

Thermal Conductivity

The thermal conductivity of grey cast iron varies slightly with composition and diminishes uniformly as the temperature rises. It varies between 0.110 and 0.137 C.G.S. units (calories per-square centimetre per second per centimetre thickness per deg. C. difference in temperature). The thermal conductivity of austenitic cast iron is lower, and again falls slightly, but uniformly, as the temperature rises. The figure for Nicrosilal is 0.07 C.G.S. units at 100 deg. C. and for Ni-resist 0.08 C.G.S. units at 100 deg. C.

Magnetic Properties

The maximum magnetic permeability of Ni-resist and Nomag are 1.03 to 1.05, and of Nicrosilal 1.1 to 1.4, taking the permeability of air as unity, ordinary cast iron having a maximum permeability of 240 and open-hearth steel a permeability of 8,350.

Electrical Properties

The conductivity of austenitic cast irons is approximately 1.25 per cent. of that of copper. The electrical resistance is about 50 per cent. greater than that of ordinary cast iron, being about 150 microhms per centimetre cube specific resistance. The resistance of Ni-resist has been given as 130 to 140, and of Nicrosilal as 160, microhms per centimetre cube.

The resistance temperature coefficient from 0 deg. C. to 100 deg. C. is low, being 0.00045 for Nomag, compared with 0.0019 for ordinary cast iron and 0.003 for open-hearth steel. The coefficient is about one-tenth of that of annealed copper or pure aluminium.

Founding Austenitic Irons

The founding of austenitic irons differs mainly from that of the grey irons in their higher shrinkage, which necessitates a slightly different size of pattern. For small castings, pattern shrinkage allowances as for grey iron will suffice, but for larger sizes $\frac{5}{32}$ in. or $\frac{3}{16}$ in. per ft. should be used. Slightly higher temperatures of melting and pouring are required, and rather more generous ingates and risers should be allowed on account of the short freezing range. Pouring of small castings may be made at 1,300 to 1,350 deg. C. Normal moulding sands can be used and any melting unit can be employed. Austenitic irons can be, and are, cast centrifugally. Shot-blasting is preferable to barrel-tumbling as a mode of finishing.

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Coke and Blast-Furnace Efficiency

M. A. MAYERS and H. G. LANDAU, of the Carnegie Technical Coal Research Laboratory, in a Paper before the American Institute of Mining and Metallurgical Engineers, described a method for controlling the properties of pig-iron and the economy of its production in blast-furnace operation. This method ascertains the particular qualities in the coke necessary to produce certain qualities and quantities of pig-iron under specific conditions of operation and ore analysis. The research showed that as the "shatter index" of coke was improved, the amount of coke needed to produce a ton of pig-iron decreased and the production capacity in a given period increased. In tests it was found that improving the "shatter index" by one point increased the rate of production by 3 per cent., while the amount of coke required to produce a ton of iron decreased. Formulæ were developed whereby blast-furnace operators may calculate the quality, economy and rate of production of pig-iron from the properties of the coke used. For these calculations preliminary data, defined in the Paper, must be collected on each specific blast-furnace operation. Although the importance of coke properties in pig-iron production was always realised, no previous scientific method for forecasting results had been worked out because of the many variable conditions involved.

Photo-Electric Detection of Incendiary Bombs

A further Specification in the series of British Standards for automatic devices for the detection of incendiary bombs has been issued by the British Standards Institution. This new Specification (BS/ARP 60) deals with the performance of special electric devices for the detection of burning incendiary bombs. There are three main types of photo-electric devices dealt with in the Specification, these being photo-conductive cells, photo-emissive cells, and photo-voltaic cells, together with their associated equipments. The Specification defines the performance of the detector in terms of operating distance, and a standard method of test to determine the operating distance is prescribed. The Specification also lays down various conditions for the general design of the equipment with a view to ensuring reliability in operation, and some instructions are given regarding the method of installation and how to carry out tests after installation. Copies of this Specification may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 6d., post free 8d.

Value of Accurate Weighing

A plea for closer attention to the efficiency of apparatus for weighing steel is made by MR. WILLIAM M. STUBBS, scale supervisor of the Acme Steel Company, Chicago, Ill., in an article entitled "Let's Use More Sense in Weighing Our Steel," published in "Blast Furnace and Steel Plant." Weighing, he says, is an important factor in the control of quality in the production line, and the maintenance of amicable customer relations is usually not given the regard due its effects by the producers of steel. Customers do not complain when deliveries exceed the invoice weights, but raw materials have been consumed, operating expenses have been incurred, and wages have been paid for the product given away. Overweights are thus a drain on the plant resources.

At an average price of $45 per ton, and an annual output of 1,000,000 tons, based on the current business practices, $225,000 can get away from the black side of the profit-and-loss account with no chance whatever of its being recovered, and not much chance of being detected. The usual allowance between supplier and customer for variation between origin and destination weights is one-half of 1 per cent. of the billed weight. One half of 1 per cent. of 1,000,000 tons is 5,000 tons. At $45 per ton, 5,000 tons amounts to $225,000. That comes directly out of the narrow margin between operating revenue and expenses from which comes business profits. It is not only one-half of 1 per cent. of the total revenue, it is a very sizeable percentage of the profits; that is, it would be if the producer had it.

It is no intemperate statement that the steel producer who says "Our weighing practices are satisfactory. We have no complaints from our customers" is either deceiving himself or making a transparent attempt to deceive others. Those who know weighing machinery and its manner of use in commerce know that an index of accurate weighing is not the absence of customer complaints, but the prevalence of kick-backs from destination weights determined by less adequate facilities than those at the point of origin.

The author concludes that "the absence of any complaints at all indicates that the origin weights consistently over-run the destination weights. In the steel business the circumstance proves only the steel producer is playing Santa Claus 365 days a year to the wide, wide world."

Mould and Core Washes

(*Concluded from page* 145)

MR. BUCHANAN was pleased to hear of a large-scale collaboration of the statement. His point was that he was scared of its ultimate effect on the sand. If there was a reasonable certainty that there would be no deleterious effect, he would certainly try the method, as it was rather novel, but would have to bear in mind the ultimate effect rather than the effect on any particular casting. His own practice, however, did not call for much improvement in cost or results.

MR. HAYNES said he used an ounce or 1½ ounces of salt to a quart of water, and he suggested to Mr. Buchanan he should try it in his mixtures and ascertain how the method worked.

Vote of Thanks

Upon the proposition of MR. H. WINTERTON, seconded by MR. F. A. HARPER, a hearty vote of thanks was accorded to Mr. Buchanan for his extremely interesting Paper.

MR. BUCHANAN having suitably responded to the vote of thanks, the proceedings of the session concluded.

Small Diameter Cupola Practice*

By WILLIAM POLA

(Slightly Abridged)

The title of this Paper would be perhaps better with the sub-title, "As Carried Out at Russell Manufacturing Company Pty., Limited," for it is a description of how the work is carried out there. As the title suggests, it deals mainly with the practical side of cupola operation, therefore figures and technical detail, such as those available in the works of Hurst, Moldenke, and others, are omitted as far as possible.

It should be borne in mind that small diameter cupolas are to be dealt with, which are more critical in their operations than the large ones. The methods to be described have proved successful in the production of metal for very fine castings and a wide range of jobbing work. Some of these methods are not given much detail in the published works on cupolas.

Furnace Lining

The most expensive items of cupola maintenance are the refractory materials. To make a good job of bricking the cupola well-fitting bricks are essential. Badly-shaped bricks which leave a gap at the joints have their life reduced to about a third of those that are well laid and closely fitted. The jointing material, usually fireclay, being less heat-resisting than the bricks, becomes burnt out first, thus exposing three or more sides of the brick to the heat instead of one side. Another factor in reducing the normal life of brickwork is the use of jointing material that is too stiff or too thick. This will not allow the bricks to bed down one against the other. Two-thirds good fireclay and one-third clean sharp silica sand mixed to a creamy consistency, just thick enough to prevent it from running, forms a good thin joint, as it allows the bricks to be hammered together as close as they will go. The irregular shape of some cupola shells, including rivet heads and angle irons for holding brickwork, are the bugbear of good bricking. Where these are encountered, the bricks should be cut at the back to make them fit. An ordinary grinding wheel is excellent for this purpose when soft bricks are used. Where abrasion is severe, owing to the nature of the scrap charges, hard bricks give good service compared with soft ones. Around the charging door, wear is usually severe. Cast-iron bricks, used in this position, will last for years.

After chipping out slag, clinker, etc., inside the cupola, patching and daubing the brickwork is the first important operation. A good grade refractory lining put on with care will do much towards a successful cast. Inferior material badly mixed and applied will, most likely, either crack and fall away from the bricks or fuse easily and run from the melting zone in the form of a thick slag. Fouling of the tuyeres, eating away of the firebricks, and a tendency to bridge are the results. A very good daubing mixture can be made with sandstone crushed in a mill, with just enough fireclay to bind it together and a small addition of red sand and coke dust. The red sand appears to supply sufficient iron oxide to frit the mixture to the bricks. Owing to the difficulty of procuring sandstone, experiments were made with sharp silica sand. The following mixture gave good results:—10 parts of silica sand; 5 parts of ganister; 3 parts of red sand, and 2 parts of coke dust.

This mixture has a gritty or sandy feeling, and is harder to apply to the cupola walls than a mixture of a fatty or greasy texture. It is important not to have a daubing mixture of a fatty texture, as it will crack into cakes and fall off during the heat. After filling a deep hole in the brickwork with broken crucibles, pieces of firebrick, etc., and covering with daubing material, it is a good plan to vent freely with a ¼-in. diameter rod. This allows steam to get away during drying and assures a good patch. Daubing material should be mixed at least one day before using, and should not be applied more than an inch or so thick without some form of solid backing. When daubing is completed, the belly or cavity at the melting zone should not be more than 2 in. larger than when the cupola was rebricked; that is, allowing 1 in.

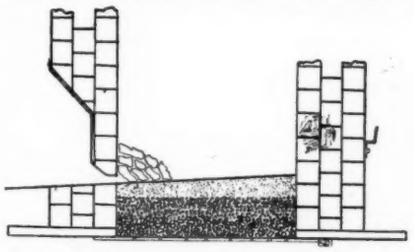

FIG. 1.—METHOD OF FORMING HEARTH BOTTOM IN CUPOLA.

of taper to take place on the cupola walls. Keeping the diameter constant from day to day is important on small diameter cupolas when carbon control in the metal is essential. The average life of the bricks in the 24-in. cupola, melting high percentage steel mixtures, is 16 weeks. The average life of bricks in the balanced blast cupola, melting no steel, is 20 weeks. Both cupolas run about 3½ hours daily. Failure to reduce blast when cupola stack is emptying cuts out daubing and bricks.

Care in maintaining the lining of the hearth will save much unnecessary work. Slag which collects there will, under certain conditions, attack the bricks and lining, quickly eating its way into the joints. Slag becomes frothy due

FIG. 2. — SPECIAL TYPE OF "BOTT" WITH OIL - SAND CORE IN CENTRE.

to rusty scrap, with insufficient limestone, low bed, basic slag and acid lining. The cavity becomes filled with metal, and to remove it often means wrecking the brickwork. If left there, it is added to with every heat and will, in time, reduce the capacity of the hearth. It also may have an effect on the temperature of the early metal from the cupola. A close-grained lining is better on the hearth walls because slag cannot penetrate it easily. Complete chipping out, and renewing the lining every two or three days, will keep the hearth in good order.

Construction of the Hearth Bottom

Construction of the sand bottom of the hearth has an effect on metal at the start of the heat. A hard, close-grained, or wet sand bottom causes boiling and dulling of the first metal, which may set in the taphole. After slag and coke has been cleared away from the drop of the previous heat, there is found fine burnt sand and slag rubble. This is put through a ¼-in. sieve, and the rubble, of about ¼-in. diameter, is placed on top of the drop doors (which are drilled with holes about ½ in.) to a depth of 2 in. The dry sand and small rubble that went through the sieve is then put in to a depth of about 2 in. below the level of the taphole and tamped down. The bottom is then built up to the level of the taphole with good moulding sand (not too damp). The slope from the back to the taphole as slight as possible, just enough to run the metal from all sides to the hole, three-quarters of an inch to the foot being sufficient slope. Painting the sand bottom with plumbago, blacking mixture, or clay wash is poor practice and unnecessary. A hearth bottom formed as described and illustrated in Fig. 1 will allow steam and gases to escape, dries quickly, and prevents boiling of the first metal.

The taphole may become blocked with dull metal, as previously referred to, and in forcing it open a large hole may be formed. Where a large number of small taps are taken off into small ladles, a bad hole is awkward to bott up and is often dangerous. If metal freezes in bott hole it may be necessary to burn a passage with an oxy-torch. The torch is applied to one end of a pipe 2 or 3 ft. long, the other end being in contact with the metal in the hole. Metal and pipe are both melted away.

It is important that the bottom of the taphole be level or a shade lower than the sand bottom. If it should be constructed above the hearth bottom level an accumulation of dull metal will build up there, causing a large blockage of partly set metal directly in front of the hole, which may be very hard to break through.

An oil-sand core, slightly smaller in diameter than the taphole, inserted down the centre of the clay bott will prevent metal solidifying in the hole. This type of bott, of course, is only used for the first bott-up at the start of the heat. The binding in the core burns away, leaving the hole full of sand, which is easily poked away after releasing the clay part of the bott from the outside. The author has used the type of bott shown in Fig. 2 for a number of years.

On cupolas having two or more linings of bricks, the hole is too long, and this may cause metal to solidify there. The correct method to overcome this is to have an inset from the outside constructed in the shell. Another method is to lay the bricks so that there is only a single lining of bricks at the taphole, tapering away to full thickness at the other parts of the hearth. The hearth as shown in Fig. 3 thus becomes egg-shaped with the small end at the taphole.

When a large number of small taps are taken from the cupola during a heat, and metal is held in the hearth for mixing, care should be taken to keep the taphole in good order. The old bott should be all cleared away from around the tapered hole so that the new bott is a snug fit when inserted. A gouged-shaped chisel bar is excellent for this purpose, as it cuts a circular hole. This is a simple tool for keeping the hole in good order when 30 to 40 taps are made in one heat.

A small, closely-packed mound of coke built around and above the hole prevents damage from wood and coke dropped through the charging door, it also prevents small coke and charcoal from sticking in the hole, blocking the flow of metal. Close attention to sand bottom and taphole will prevent trouble at the beginning of and during a heat. Owing to additions to the foundry, it was found necessary to have two tapholes on the cupola, one at the front and one at the back where the fettling

* A Paper read before the annual meeting of the Australian Institute of Foundrymen. The author is Head Furnaceman, Russell Manufacturing Company Pty. Limited, Melbourne.

Small Diameter Cupola Practice

door used to be. The door was moved to the side, opposite the slag hole. The slope on the sand bottom is made to the front hole, as that is the one opened first. Only large taps are taken off at the back. This arrangement works very well.

Launder Additions

Some cupolas have funnels or spouts fitted over the shute, used for ladle additions of chrome, silicon, nickel, etc. A simple funnel is better than hand feed for alloys. If the level of the shute is made slightly below that of the taphole, the metal will form a fan-like stream directly in front of the hole. Ladle additions dropped there from the funnel will be swept away into the ladle without fouling the bottom or sides of the shute. Additions put in the metal this way are well on the way to a molten state by the time the end of the shute is reached, and the stream action in the ladle stirs it thoroughly.

Coke

Poor coke, low in carbon and high in ash and sulphur, cannot produce the best metal. The degree of porosity and the size of the pieces of coke has an effect on cupola operation. Hard, dense coke has strength to resist crushing by metal charges and will allow higher blast than the more porous light grade. Very light and excessively porous coke tends to burn away before reaching the melting zone, lowering the bed height, causing faster melting with loss of temperature and oxidation. Medium weight coke, not too dense in structure and broken into sections of about 4 in. is best for small diameter cupolas. Large coke has less surface area than small, and does not give up its carbon as freely as the small pieces will; that is, a 10-lb. piece of coke has less surface than if broken up into small pieces. It has been noted that hard, dense coke leaves a dirtier melting zone after the drop, also tuyere openings do not keep as clear as when using the softer or more porous coke. Hard dense coke tends to make tuyeres black and dirty.

If the blast is supplied by a fan that is not positive, fouled tuyeres may restrict the air output and the tuyeres have to be cleared frequently. Excessive poking of the tuyeres may let down the bed height, causing oxidation and dull metal. Charging heavy, dense coke in big pieces causes large spaces in the stack, giving free access to the blast, which may allow free oxygen to the melting zone with an oxidising tendency. High blast and free oxygen in the melting zone gives quick oxidation. Over a period of years of cupola operation, only two occasions of this type of oxidising have been noted, once in the balanced-blast and once in the ordinary cupola. The metal, in both cases, showed signs of oxidation, pronounced mushroom-shaped heads and faulty castings. Metal from the cupola operating for piston rings showed masses of pinholes in the castings and runner heads were mushroom shaped. Metal from the cupola operating for jobbing work showed very prominent mushroom heads and large draw holes in the castings under the heads. On checking the day's operation, it was found that large lumps of coke had been charged and that blast pressure was low, low pressure being consistent with loosely-packed charges in the stack. The only metal affected was early in the heat. It may be thought that loss of bed height caused the trouble, but as great care is taken that the bed is burnt up according to a standard procedure every day and that, on the occasion referred to, melting rate appeared a shade slower than usual, loss of bed height was discounted.

Where carbon pick-up in the metal is desired for castings such as piston rings and some medium percentage steel mixtures that happen to be running a shade low, it can be obtained to some extent by maintaining a high bed, by increased coke splits, melting freely with as mild a blast as possible, avoiding shut-downs and holding plenty of metal in the hearth before tapping.

Increased splits with suitable blast make for high temperature in the melting zone, which is favourable for carbon pick-up. Care must be taken with increased splits, too much coke slowing the melting rate and upsetting the balance which must be held between melting rate, height of bed, and blast.

Sufficient limestone or some other form of flux should be used to make the slag fluid enough to run freely. Thick, very black slag is a sign of oxidation in most cases. The best slag colour being a dark shade of green. When slag is thick, it tends to foul the coke surface, preventing carbon absorption and slowing melting rate through fouling the tuyere openings and upsetting blast entry.

Burning up the Coke Bed

A properly burnt-up coke bed of the correct height lays the foundation for a successful cast.

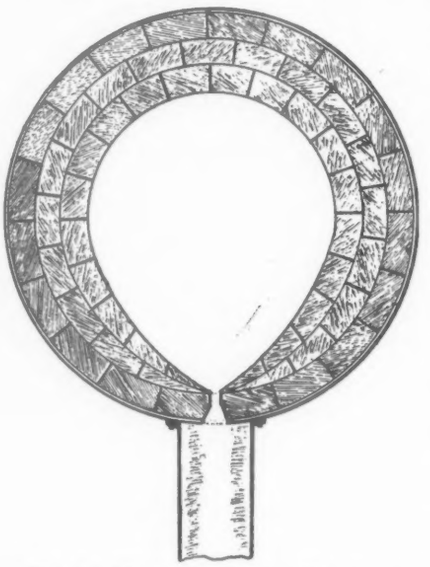

FIG. 3.—METHOD OF LINING CUPOLA TO AVOID LONG TAPHOLE.

On setting the wood fire, it is essential that the wood covers the whole area of the sand bottom, and be built up evenly all over from 12 to 14 in. depth of wood. Should the wood be put in unevenly or built up in the form of a cone in the centre, the following coke is tumbled right to the sand bottom. This causes the fire to burn up in the middle, leaving the outside quite cold and slows up the burn for a considerable time. A fire in this condition can burn up well above the tuyeres in the centre of the cupola, leaving the coke at the tuyeres quite black. Should the cupola be charged and blast put on, with a bed in a partly-burnt condition, trouble with dirty tuyeres, dull metal and a tendency to bridge may occur. The first molten metal falls on cold coke and partly-dried cupola walls; on solidifying there, it forms an obstruction at the tuyere openings.

Using the natural-draft method of burning up the bed of the balanced-blast cupola, it was found, on favourable days, that successful results were obtained. On the other hand, when wet coke was used or the wind was in the wrong quarter for a good natural draft, the burn-up was delayed, thus upsetting the time set for putting the blast on for the heat. Then, again, when the wind assisted the draft, and perhaps using dry, high porosity coke, close watch had to be kept to prevent over-burning of the bed. An over-burnt bed is more of an evil than an under-burnt one, for very light castings. The coke becomes ashed and, when the blast is put on, burns away quickly, letting the top of the bed down below the level best suited for melting. Dull metal, probably oxidised, with faulty castings, is the result, especially with piston rings.

To overcome these difficulties and to try to standardise the burn-up, the following method of blowing up the bed was adopted. Coke is placed on the correctly set wood fire and allowed to burn to a dull red to about 12 in. above the main tuyere line. Soft blast is then put on, and the coke built up a few forksful at a time. As soon as the coke shows red on top, more coke is added, a little at a time, until it is burnt up to about a foot below bed level. The blast is then cut off and the tuyeres poked to settle the coke down. More coke is then added to bring the bed up to its correct height. The cupola is then charged and the blast put on for the heat immediately. Good results are obtained in this way, and there is rarely more than a minute out in producing metal off the shute from day to day. Mild blast should be used for blowing up the bed. Fierce blast has a tendency to burn coke away before the fire is through to the top of the bed.

While building up the bed, small quantities of coke should be fed in at a time. If a large quantity is put on, the blow-up takes longer and coke just above the tuyere line is likely to burn away. When this happens, metal off the shute may be up to 5 min. earlier than usual. Faulty castings, blowholes, or chill in early metal follows. It is very important to use mild blast and feed coke on to the bed, small quantities at a time. An additional 30 in. depth of coke can be burnt through in from 5 to 7 min.

Working a balanced-blast cupola holding 30 cwts. to the charging door, and using the standard practice of burning up the bed, the blast on for the heat is 2 hrs. from lighting the wood fire. This time could be reduced, but 2 hrs. are preferred, because during that time the cupola can dry out properly and the bricks are well heated up. By keeping records of starting times of heats, the tonnage melted, and the finishing times over a period, the time required to melt and cast any given quantity of metal is known. The furnaceman is supplied with an accurate estimate of metal required for the cast, and, knowing the time required to melt that quantity, he is able to set the starting time of the heat. By allowing 2 hrs. for blowing up the bed and charging to the door, he knows the time to light the fire. Thus the cupola practice is fairly standardised and the same conditions can be obtained from day to day.

Burning up the Bed by Natural Draft

This method of burning up is the most commonly used, and providing care is taken it is most successful. It is necessary frequently to observe the condition of the fire through the tuyere holes and the charging door. Just enough coke should be put on at a time to keep the fire drawing freely and evenly. Coke charged in excessive amounts at a time has a blanketing effect on the fire and retards the burning through. Should one or two tuyeres remain black, it is best to restrict nearly all air from them; if the tuyeres are left open, the fire has to burn back into the tuyere entry, against the draft. This action is somewhat similar to burning a firebreak against the wind. When the draft is shut off, the fire will rapidly burn back to the tuyere entry, where, as soon as the coke is red, the air may be admitted again. Adjustment of tuyere shutters then will enable the fire to be burned up evenly over the entire

(*Continued on page* 146)

Mould and Core Washes

DISCUSSION AT MANCHESTER CONFERENCE ON Mr. Wm. Y. BUCHANAN'S PAPER*

During the proceedings of Session "A" of the recent Manchester Conference of the Institute of British Foundrymen, presided over by the Vice-President, Mr. D. H. Wood, the Paper on "Mould and Core Washes" presented by Mr. William Y. Buchanan was discussed by the meeting.

MR. H. T. WINTERTON (Chesterfield), opening the discussion, said he was pleased to notice that the author of the Paper recommended the use of mixers of some type rather than the old-fashioned method of using a blacking bosh, into which much extraneous material could get.

Mention was made of the use of coal dust as an ingredient in blacking. For how long and how did Mr. Buchanan mix the coal dust, and what percentage of it was he able to get into his blacking without frothing?

It was stated also that most blackings were made with a base of coke breeze. This might be correct in regard to the old-fashioned blackings and of common blacking, but it was probably not generally true of modern blackings. A typical mixture of blacking was given as being 224 lbs. of blacking to 12 lbs. of plumbago, which was something in the order of 6 per cent. of plumbago. Had such a small addition of plumbago any real effect upon the skin? If it had, it was because the common blacking, being used, required a small amount of plumbago in order to give it some sort of smoothness, which should not be at all necessary with the modern type of blacking.

MR. BUCHANAN thought there could be no doubt concerning the value of using a mixture in place of the old methods. There was little or no frothing when coal dust was used in blacking; in fact, he did not know whether such an effect would be likely to occur. Personally, he had not noticed any, and the mixture appeared to be quite uniform and free from separation or even any form of frothing on the top. The length of time of mixing was not altered in any way by the addition of coal dust. The idea originally was that it might help to prevent the usual flaking off or blowing away of the dry black wash. What was hoped would result was a slight coking or fritting together of the coal dust at the usual stoving temperature. He did not know whether it actually took place or not, but the blacking he was using was of a cheap quality, consistent with giving reasonably good results. Probably this would be considered to be an advantage in the case of most foundry managements, as there was no useful purpose served by using an expensive material if a cheaper one would serve. A small addition of plumbago effected a slight improvement which might again be dependent upon the particular type of blacking, and might not apply when a more expensive type was used. He thought the particular mixture used was arrived at gradually by a method of trial and error and bearing in mind the original cost of the blacking.

Silica Washes

MR. WILSON mentioned that there had been an absence in the Paper of any allusion to silica washes as distinct from blacking washes or carbon washes. He understood that Mr. Buchanan was conversant with a wide range of silica washes.

MR. BUCHANAN replied that silica washes did not enter very much into the particular subject, although he had tried one or two with not very good results. There was more success experienced with the kind of black wash dealt with in the Paper. As far as mixing silica washings was concerned, no difference in technique appeared to be necessary; the purpose and application, he thought, depended upon individual practice.

Bentonite Additions

MR. CLIFFORD asked how Mr. Buchanan added the bentonite, and whether he preferred it to be dry before he added it to his mixture? The reason for adding bentonite appeared to be in order to keep the particles in suspension in the liquid, and by using a mixer the amount of bentonite in suspension was reduced.

If there was an addition of a thin oil to the blacking would it serve the same purpose? What would happen, when using a heavy compo wash in conjunction with a suitable mixer?

MR. BUCHANAN said that dry bentonite could certainly be added to the water provided there was some form of pump or grinder incorporated in the equipment. He had not tried mixing with air alone. The process was certainly hastened if the bentonite was mixed preliminarily with water in a bucket, or at any rate made into a soft mud and thoroughly wetted.

Core oil of any type of linseed-oil base could certainly be used to replace bentonite as long as it was borne in mind that the core oil might be completely burnt out at some of the stoving temperatures. At a high temperature bentonite was much better.

Preparation of Thick Blacking

MR. H. HAYNES inquired whether Mr. Buchanan adopted the new method of mixing blacking of the "stiffer" type. At some foundries with which he had been associated they had had to cast jobs in which they could not use liquid blacking; it had to be applied as a thick paste. Had Mr. Buchanan any method he could recommend of mixing such a thick blacking?

MR. BUCHANAN had not pursued his investigations to the extent of seeing what sort of mud could be mixed in a mixture of that type. If there was a strong pump in the arrangement he believed it could be done. The material mentioned in the Paper had been prepared solely for application by spraying, and was of a consistency suitable for the purpose. It would certainly be too thin for the purpose mentioned by Mr. Haynes.

MR. H. WINTERTON (past-president) thought it was quite possible that in striving after cheapness in facings production Mr. Buchanan was adding to his costs in another part of the foundry. The object of having facings on moulds was to prevent the molten metal from seeping into the sand walls. So long as this was prevented, even though there was an extra cost of ½d. per ton of castings, or thereabouts, it would be an extra expense which would be thoroughly justified. It was not always advisable to strive after a cheap article when better and more economical results could be obtained by the use of a material which was based upon something which was a little more refractory and a little more calculated to carry out the duties required of it than the coke breeze which Mr. Buchanan assumed to be the best of all facing materials. This may have been the case many years ago, but he could assure Mr. Buchanan, and he believed he knew something about the subject, having spent all the working years of his life in the study of it, that to-day the basis of the facings in general use was not coke breeze, but something very much more of a refractory nature. Mr. Buchanan had admitted that, in order to obtain the results referred to, he mixed in a certain proportion of a high-grade material. This would make the cost of his production very much dearer.

Mr. Buchanan would have to revise some of his opinions with regard to the bases which were introduced into the make-up of modern facings, one of which contained seven ingredients, only two of which were mentioned in the Paper.

MR. BUCHANAN said it had certainly occurred to him that it was possible to be penny-wise and pound-foolish. Unfortunately, he was responsible for both ends of the problem; the castings going out as well as the materials bought for the facings. Therefore he could not make a good showing in one department and put blame on somebody else in another. He had to shoulder the responsibility in both cases.

The question of whether the sand would peel away properly from the castings would very quickly be brought to his notice. He thought Mr. Winterton would have to take it as definite that the condition of the casting was the first consideration. Probably they would be in agreement that, no matter how good a blacking was, it would not get a proper chance unless it was mixed by some mechanical method which was free from the old troubles. It was certainly possible to get a good machine which would mix everything properly, but there were others which were not particularly effective.

Another point he wished to make was that the few notes he had prepared were merely a record of his own views from the experience of the past ten years or so. Most of those present would have arrived at similar opinions during that course of time.

Coke breeze was one of the commonest materials to use. He had listened very carefully to Mr. Winterton in case he mentioned anything else, but he had not done so. It was useful information to learn that some other blackings were actually better and justified their higher expense.

Salt in Blacking Mixtures

MR. H. MORRIS noticed that Mr. Buchanan had stated that the object of the bentonite admixture or that of core oil, dextrine, crude oil and Colbond was made in order to prevent the blacking rubbing away after drying. Had he tried common salt for this purpose? It was probably a much cheaper method than using up core oil, etc.

MR. BUCHANAN had not tried common salt, and would be rather scared of doing so unless he heard of someone else trying it first. The soda contamination of sand was one of the worst materials for reducing refractoriness. He would like to hear of salt being tried on at least a small scale. Salt might contaminate the floor sand for a long time, and then perhaps unexpectedly its refractoriness would be reduced and it would have to be renewed. He was thinking of tests at elevated temperatures.

MR. HAYNES said he had tried salt water on a casting which cost £300 to make. It was as blue as any casting could ever be expected to be. The practice had now been introduced throughout the foundry, and salt was a regular constituent of the blacking. The core-man could rub his jacket against the side of a mould and not rub off any blacking. This was the reason why he had mentioned the point concerning sea-water acting on the sand in his contribution to the discussion of the American Exchange Paper.

(*Concluded on page* 142)

* Foundry Trade Journal, July 31, 1941, pp. 73-75.

Price-Fixing Procedure in the Iron and Steel Industry

ALLOWANCES FOR INCREASE

A report by the Committee on Public Accounts, published last week by the Stationery Office (6d.), contains the Committee's observations on the price-fixing procedure for various materials, among which are iron and steel products and machine tools.

The report points out that Public Accounts Committees of recent years have given considerable attention to iron and steel prices. These prices were based on costs of production investigated by an accountant appointed by the Iron and Steel Federation, a body representative of the industry as a whole, and reviewed by the Import Duties Advisory Committee, who had the assistance of an advisory accountant. Although this procedure was established for reasons other than to satisfy Government Departments that they were paying reasonable prices, Departments in general accepted the Federation's prices without any further cost investigations.

In these circumstances the Committee examined in some detail the position since September, 1939, when the statutory control of the industry was established. It was explained that the Iron and Steel Control, whose staff is paid by the Iron and Steel Federation, have the necessary technical knowledge and information to make recommendations, but the control is done by authority of the Minister of Supply with the advice and assistance of the Accounting Officer and his administrative officers. The control prices adopted at the beginning of the war were generally those shown in the current price-lists of the constituent associations of the Federation, and they have since been increased to cover increases in costs verified by the accountant appointed by the Federation.

Quarterly Ascertainments of Profits

The Comptroller and Auditor-General reported that no investigation on behalf of the Minister of pre-war or current costs had been brought to his notice. The Ministry explained that they had considered it essential to maintain the uniform pre-war prices, but arrangements had since been made to extend the investigations conducted by the accountant appointed by the Federation, and these investigations cover basic costs and not merely the increases. The advisory accountant originally appointed by the Import Duties Advisory Committee now advises the Ministry on prices after he has considered the weighted average costs of production ascertained by the investigating accountant. More recently, provision has been made for examination at quarterly intervals of the profits made by different firms in the main industry to see that the uniform prices based on average costs do not give undue profits to individual firms on their production as a whole, and a scheme is at present under consideration under which allowances for increased costs will be given only to producers whose profits would otherwise be unduly reduced.

The Comptroller and Auditor-General stated that he had recently received the summaries of the weighted average costs, but that no written reports of the investigating or the advisory accountant had been furnished to him. In the absence of knowledge of the basis on which the costs were founded or the details from which they were built up, he was not in a position to express any opinion on the adequacy of the current arrangements for determining prices. The Committee understand that in general investigations have not been made by the Ministry's own cost accountants, but that the costings clause which is now included in all iron and steel contracts will be brought into operation when the quarterly examination shows that a firm is making undue profits.

Payment for Imported Scrap

The Committee were also informed that, to facilitate the use of imported scrap, the Federation had made arrangements before the war for a levy on producers of basic products. This levy and further levies to meet certain additional wartime costs have been included in control prices. It appears also that in this connection advances have been made from the Exchequer, but the Comptroller and Auditor-General has hitherto had no access to the accounts of the funds which appear to be maintained for the purposes mentioned.

The Committee regret that the results of their examination have not given them sufficient information on which to base any conclusions regarding the price-fixing arrangements in the iron and steel industry. It was admitted that the arrangements explained to them in evidence had only recently been made, and had not yet been tested and carried through. The Committee must rely largely on facts reported by the Comptroller and Auditor-General and he has not yet been enabled to give any assistance. They are therefore glad to be assured that the Ministry are prepared to ensure him access to all information on which the control and contract prices are based. They also recommend that, apart from the cases in which firms are found to be making undue profits, the Ministry's own accountants should cost a certain number of contracts, including sub-contracts of Government main contractors.

Staffing of the Steel Control

The Committee make observations also in regard to the Iron and Steel Control on "dual capacity," that is, the conditions which should attach to the appointment of posts in Government Departments of individuals holding responsible positions in outside industry. During the year under review the staff of the Iron and Steel Control was paid by the British Iron and Steel Federation. The Accounting Officer stated that the whole staff have now had their attention drawn to the fact that they are servants of the State and of the Control, which is an instrument of the Ministry of Supply. Public Accounts Committees in recent years have had occasion more than once to refer to the relations between Government Departments and the Federation, as representing the industry, and in the circumstances the Committee were glad to receive the definite assurance that the Control is exercised by authority of the Minister. After instancing other somewhat similar arrangements, the Committee go on to state that, while they recognise that it is no doubt essential for the efficient working of the control system to use the services of such associations, it must be realised that this system raises in an acute form the problem of dual allegiance, and every care should be taken to safeguard the public interest. It may be added, they state, that the remuneration of the higher officials, indirectly paid from public funds, is likely to be greater than if they had been in the direct employment of the Ministry.

Prices of Machine Tools

On the question of machine-tool prices, the report states that since the beginning of the rearmament programme successive Public Accounts Committees have considered the question of securing an effective check on the reasonableness of prices paid for machine tools in the face of the refusal of the trade to accept costings. Some progress appeared to have been made when, on June 14, 1939, the House of Commons was informed that the Machine Tool Trades' Association had agreed on behalf of their members that a discount of 5 per cent. should be given on all standard tools for the defence programme delivered after December 5, 1938, and that non-standard tools should be costed if the Government so desired. The arrangement which was to be in force for one year, and to be subject to renewal, lapsed from December 6, 1939, consequent on the Minister's decision to institute a Statutory Control of Machine Tools, and the Public Accounts Committee of 1940 were informed that there was provision for costings in all contracts placed after December 5, 1939. These changes should have provided full information, but the Comptroller and Auditor-General reported that the 1939 arrangement had not in fact been accepted by all members of the association.

(*Continued at foot of next column*)

(*Continued from previous column*)

In view of the difficulties encountered, which appear to have been due to the ill-conceived attitude of a minority of the firms engaged in the industry, alternative methods have been adopted under the Control to secure reasonable prices for machine tools. The latest scheme fixes provisional prices from July 27, 1940, on the basis, generally, of 1935 prices plus 22½ per cent. The Committee were glad to receive the assurance of the Ministry that, notwithstanding the regrettable history of this matter, the industry has been successful in effecting a remarkable expansion without, so far as the Ministry's present information goes, receiving unduly large profits. The Committee trust that the working of the new scheme will justify the hope expressed that it provides a satisfactory solution of the difficulties previously experienced, and that the prices fixed under it will be shown to be fair and reasonable.

Small Diameter Cupola Practice

(*Continued from page* 144.)

surface of the coke. Once the coke is well alight around and above the tuyere line, the fettling door may be closed.

At this stage of the operation close control should be kept for any hanging up of the coke, which causes spaces in the bed. An important part played in obtaining a solid bed is poking the tuyeres with a long solid bar. More is required than just pushing the bar straight in; it is necessary first to settle the coke hard into the hearth, then poke the coke down from the sides and top of the tuyères, making as solid a mass as possible of the coke. This should be done at least two or three times during the burn up, the last occasion just before charging the first metal into the cupola.

Ensuring Initial Hot Metal

To carry this out, a bed measuring rod, marked in two places, is needed—one mark being the final bed height, the other two-thirds of the bed height. Supposing a bed of 36 in. is required (measured from the top of the tuyere openings), coke would be put on to a height of 24 in. and allowed to burn through hot, so that cupola walls are well heated. Having reached this stage, the additional 12 in. of coke is added and the cupola charged immediately. The earlier the blast is put on after the start of charging the better. The first charge should be of a fairly even section material, avoiding excessively large or small scrap. A bed burnt up as described will give hot metal initially.

Several years ago experiments were made with soaking the charges before putting the blast on. The cupola was charged and allowed to stand for varying periods up to two hours. The time was taken from the completion of charging up to the door. It was found, on all occasions, that soaking gave dull metal with faster melting for the first two or three charges. It may be thought that the bed had burnt away during the soaking, but as only a small draft of air was admitted, some other explanation was sought.

Previous to the soaking experiments, it had been noted that when very light scrap was charged on the coke bed the first metal was dull. The light scrap would quickly absorb heat from the bed coke while the cupola was being charged. Therefore the explanation of dull metal from soaking may be that the charges become heated right through to a more or less soft mass. When the blast is put on, it falls through the bed coke in a pasty state, picking up enough temperature on its way to make it run without being hot. There may be some other reason for this failure to get higher tapping temperature after soaking the charges.

(*To be continued.*)

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The Week's News in Brief

Trade Talk

A WINDING-UP ORDER was made in the High Court on July 28 in the case of Sussex Ironworkers, Limited, Ladymede Berkeley, Gloucester.

FOR THE CURRENT SEASON to July 1 Lake Superior ore shipments totalled 28,825,566 tons, a gain of 67 per cent. over the 17,268,690 tons in the corresponding period last year.

AN APPLICATION for a winding-up order for the Cadmium Plating Company, Limited, of John Street, Sheffield, was granted by Judge R. C. Essenhigh in Sheffield County Court.

OFFICIALS of the Boilermakers' and Iron and Steel Shipbuilders' Society are to meet both the engineering and shipbuilding employers in the near future to discuss wage questions.

A PLAN for the interchange of tools vital to war production was initiated at a conference in Birmingham attended by representatives of over 40 engineering firms from five Midland counties.

CLAIMS FOR A substantial advance of wages were presented by the unions when representatives of the Shipbuilding Employers' Federation and the Confederation of Shipbuilding and Engineering Unions met at Carlisle.

UNDER AN Indian Government Order which came into force on July 21, nickel, zinc or spelter and electrolytic copper will be controlled. The Order requires stockholders and dealers to obtain licences. Sales can be made only under permit.

PLANTS have been erected by Charles Hardy, Inc., New York, and Electro Metallurgical Corporation, Sault Ste. Marie, for the production of calcium, a metal much used for the refining of aluminium scrap, and in magnesium foundry practice.

IRON AND STEEL SCRAP WORKERS have been given a minimum wage of 1s. 4d. an hr., or 64s. for a 48-hr. week. The award has been made by the Joint Conciliation Committee recently set up to regularise relations between employers and employed in the industry.

THE BOARD OF TRADE have made an Order prohibiting all exports to Japan, including Karafuto, Japanese mandated islands, Korea, the Kwantung Leased Territory, Formosa, and Manchuria, except under licence. All outstanding export licences for these destinations are being revoked.

A BLUNT DEMAND to employers to release more women for munition work was made by Mr. E. W. Barltrop, Regional Controller for the West Midlands, when speaking at Birmingham. He wanted at least 50,000 more women for factories in the Midlands before Christmas, he said. Production was being held up for the need of their services.

THE TREASURY has certified cobalt, copper, gold, iron, manganese, tin, tungsten, vanadium and zinc, and crude petroleum, for the purpose of the provisions of Section 31 of the Finance Act, 1941, relating to the allowance to be made for Excess Profits Tax in the case of industries engaged in producing metals and oil of exceptional importance for the prosecution of the war.

ISCOR, the South African iron and steel works, announces that amongst recent additions to its plant is a new—the third—blast furnace; two 25-ton acid converters; a 750-ton mixer; and two 100-ton travelling cranes to span a new heavy steel foundry. In addition, the rolling mills, sheet mills and power station have been extended. Taken together, a very important contribution has been made to the industrial resources and war potential of the Dominion.

ERRONEOUS OR GREATLY exaggerated reports concerning idle time in war factories are the subject of a circular letter issued by the North-West Regional Board of the Production Executive. Rumours and reports suggesting or definitely alleging slackness, idle time, and faults in management in munition works and factories have recently been the cause of considerable anxiety on the part of the Regional Board. The circular letter, signed by Sir Frederick J. West, the chairman, has been issued as a corrective. The statements and rumours in question, says the letter, are creating a feeling of uneasiness in the public mind, and are calculated to damage the prestige of this country in the minds of our allies and neutrals. Also, they furnish our enemies with material for propaganda. The Board have, through several channels, investigated some of the statements in question, and have found in the main they are erroneous or greatly exaggerated. There has, however, been a certain amount of idle time in some factories, not through fault in managements, but primarily arising through interruptions in the flow of materials, certain bottlenecks in production, and other unavoidable causes. It is quite possible that arising from these difficulties idle time will occur in the future, and it is suggested that when such occasions arise managements should take the workpeople into their confidence through their most appropriate channels for imparting information of this nature, and explain fully the reasons for hold-ups and interruptions which result in idle time.

Personal

MR. WILFRED B. BEARD is the new general secretary of the United Patternmakers' Association.

MR. ALBERT ELLIS, managing director of Peglers, Limited, brassfounders, is the first president of the newly-formed Doncaster Chamber of Commerce.

MR. G. SPENCER SUMMERS, M.P., has been appointed by Lord Beaverbrook, Minister of Supply, to be Controller of Area Organisation. Mr. Summers is a director of John Summers & Sons, Limited, steel manufacturers.

MR. J. HERBERT ASTON has been appointed chairman of Tube Investments, Limited, in the place of the late Mr. Arthur Chamberlain. Mr. I. A. R. Stedeford has been appointed managing director, and Messrs. P. G. Carew and W. Hackett, jun., assistant managing directors. Mr. J. Herbert Aston relinquishes the appointment of joint managing director.

MR. J. S. PECK, who has retired from the position of chief electrical engineer of the Metropolitan-Vickers Electrical Company, Limited, has written a parting message to the August issue of "A.E.I. News," the magazine of Associated Electrical Industries, Limited, in which he surveys 50 years' service in the electrical industry. Mr. G. A. Juhlin has succeeded Mr. Peck in the position of chief electrical engineer.

Wills

HUGILL, JAMES, of the Hugill Forge and Engineering Works, Stockton-on-Tees £335

BROWN, J., of Greenock, managing director of Scotts' Shipbuilding & Engineering Company, Limited £42,232

HOLMES, P. F., of Huddersfield, chairman of W. C. Holmes & Company, Limited, engineers £58,135

JACKSON, J. S., of Wakefield, secretary of E. Green & Son, Limited, fuel economiser manufacturers £5,265

CHADDERTON, F. W., of Oldham, a former director of Platt Bros. & Company, Limited, textile and general engineers £26,077

DEAN, EDWARD GEORGE, of Halifax, engineer, and secretary and manager for Henry Broadbent, Limited, machine-tool makers, Sowerby Bridge, Yorks £7,979

FOSTER, LIEUT.-COL. JAMES YATES, of Penwortham, Lancs, formerly governing director of Joseph Foster & Sons Limited, Preston and London, newspaper machine engineers £20,560

Obituary

MR. RENDELL DAVIES was accidentally drowned on a recent holiday in the Midlands. By his death, specialist engineering services associated with building have suffered a severe loss. Mr. Rendell Davies had been in practice as a consulting engineer in London for many years. He was an active member of the Lifts and Escalators Installation Panel, and, as chairman of the Drafting Sub-Committee of that Panel, played a leading part in the drafting and publication of the first code of practice for the installation of lifts and escalators ever published in this country. Mr. Davies was also actively associated with the work of the British Standards Institution.

MR. ARTHUR BLAIKIE PURVIS, who was killed in the air-liner accident recently, was the head of the British Purchasing Commission in the United States. He received from the Government a nominal salary of one dollar a year. He entered Nobel's Explosives Company at an early age and made speedy headway. He was given an important position in Imperial Chemical Industries, Limited, when that combine was formed, and in 1924 went to Montreal as president of Canadian Explosives, Limited. He was appointed Director General of the British Purchasing Commission in the United States in January this year. Before that he was president of the Anglo-French Purchasing Commission, a post to which he was appointed in December, 1939. In December last year he was sworn a Privy Councillor.

New Companies

("Limited" is understood. Figures indicate capital. Names are of directors unless otherwise stated. Information compiled by Jordan & Sons, 116, Chancery Lane, London, W.C.2.)

Lakeside Ironworks, Alfred's Way, Barking, Essex—£5,000. L. E. Brain.

Glamorgan Metal Refiners, 8, Bonvil Terrace, Swansea—£2,000. T. T. Lewis.

Buma Engineering Company, Robson Street, Newcastle-upon-Tyne, 6—£15,000.

Victoria Coal & Iron Company, 2A, Princes Street, Wellington, Salop—£1,000. C. H. Whorton.

Tool Developments—£2,000. A. Mitchell, "Beechdene," Halton Hall Estate, Halton, Lancs; and F. Fox.

J. Davenport, 37, Bankside Street, Oldham—Iron railing makers. £3,000. G., M., and W. H. Davenport.

M.B.W. Plating & Engineering Company—£1,000. J. T. Mace, 510, Hurst Road, West Molesey, Surrey, subscriber.

Kneller (Instruments & Tools)—£500. C. J. Kneller, "Brooklyn," Dunchurch Road, Rugby; and Eileen M. Kneller.

Smith & Timmington, Button Works, Cox's Lane, Old Hill, Staffs—Engineers, etc. £500. T. Smith and I. Timmington.

Tool Makers (Morecambe)—£5,000. W. J. Neild and W. F. Altham, 13, Branksome Drive, Morecambe and Heysham.

C. G. Wade—Manufacturers of and dealers in machinery, plant, etc. £50,000. C. G. Wade, 9, Bank Street, Rugby, subscriber.

Gilbert T. H. Clayton—Engineers, etc. £2,000. G. T. H. Clayton, Cobbles, Broadstone, Dorset; Alice Clayton and C. I. S. Chappell.

Turpin, Nott & Murfitt, 2, Hendon Lane (rear part), London, N.3—Engineers, etc. £1,000. J. L. Murfitt, S. E. Nott, and C. C. Turpin.

Lawrence Dies & Machine Tools—£500. J. R. Maudsley, The Cliff, Cliff Hall, Warwick; A. D. Rawlinson, and H. A. J. Lawrence.

Reports and Dividends

Barton & Sons—Dividend of 5% (same).

Quirk, Barton & Company—Interim dividend of 2½% (same).

Light Production—Final dividend of 1s. per 5s. share, making 25% (10%).

Rippingilles—Profit to March 31, £10,029 (£10,397); ordinary dividend of 6% (7½%).

Howard & Bullough (Securities)—Profit to March 31, £35,963; dividend of 4% on the ordinary stock.

Silentbloc—Profit to May 31 last, after depreciation, £136,121; taxation, £111,534; dividend of 6d. per share.

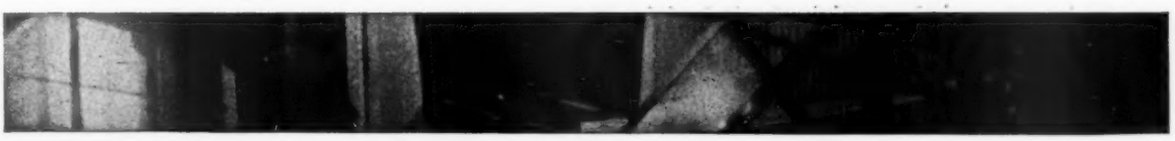
A. & J. Main—Profit for 1940, after depreciation and taxation, £18,855; brought in, £5,569; dividend of 10% on the ordinary shares; to reserve, £7,500; forward, £5,980.

Wellman Smith Owen Engineering—Net profit to March 31, £77,019 (£79,793); taxation, £41,800 (£40,000); net profit, £35,219 (£39,793); final ordinary dividend of 5% (same), making 10% (same), and a cash bonus of 2½% (same).

James Howden & Company—Profit, £80,053 (£84,785), after depreciation £20,545 (£12,680) and war damage insurance £4,543 (nil); dividend of 15% (same); taxation, £24,000 (£30,051); to general reserve, £20,000 (same); forward, £18,046 (£17,693).

Engineering & Lighting Equipment—Trading profit to March 31, £58,347 (£54,521); tax and E.P.T., £39,500; net profit, £18,469; preference dividend, £6,229; final dividend of 4% on the ordinary capital making 10%; forward, £4,533.

Head, Wrightson—Trading profit for the year to April 30, after A.R.P. expenditure and war damage insurance, £181,177 (£139,151); net profit, after tax and depreciation, £15,443 (£22,516); final dividend on the ordinary shares of 3½%, making 6% (same); forward, £21,243 (£21,612).



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Raw Material Markets

There continues to be ample work available for the heavy-castings section of the engineering industry, and it is likely that specifications from Government departments will ensure full-scale operations over a long period. The volume of Government work placed with the light-castings trade, however, has at no time been of any real consequence, and there is no indication that there will be any material change, as only a comparatively few of these foundries have been able to adapt their plant to cope with the products required for the war machine. Ordinary domestic trade in light castings has been at a low ebb for a long time past, while the amount of export business which may be conducted bears little relation to pre-war days. It is because of the quiet condition of the light-castings industry that supplies of high-phosphorus iron are available freely, though this type of iron is now being utilised more extensively than in the past, as it is being incorporated in the mixtures of heavy engineers, who cannot procure all the low-phosphorus iron and hematite needed to operate their plant at full capacity. The Iron and Steel Control have still a supply of imported hematite, but this is only being allocated to users of the highest priority.

Pig-Iron

MIDDLESBROUGH—Local foundrymen are drawing their supplies of iron from Derbyshire and Northamptonshire producers, as furnaces on the North-East Coast are engaged in satisfying the heavy demand for basic qualities required for steel-making purposes. Deliveries of foundry iron are quite adequate, so that the absence of Cleveland iron production is not a serious problem. In any case, consumption is rather lower than it was before the war, as the scope of the light-castings industry has been appreciably curtailed, only a limited amount of home business being available, while the volume of export trade sanctioned by the authorities is not anything like sufficient to counteract the loss of other outlets. Government demands on the trade have been very disappointing, and no high hopes are held of there being much improvement in this direction, as the needs of the war machine are largely associated with heavy castings, makers of which are pressed for deliveries.

Strenuous efforts have been made in past months to economise in the use of hematite, and the fact that supplies of the latter are now distinctly easier is an indication of the success which has been achieved. Economy has been effected by the more widespread use of high-phosphorus and refined irons and scrap. Every ton of hematite which becomes available is readily taken up, but priority consumers who cannot easily utilise substitutes are getting supplies through with less delay.

LANCASHIRE—Foundry iron is in heavy demand by makers of machine tools and electrical and other specialised foundries, all of which are in possession of full order-books. Heavy foundries generally are employed extensively on contracts associated with war work, whereas textile machinists, light and jobbing foundrymen rely more on ordinary domestic orders, which are not offering at all freely, so that consumption of iron in these sections is reduced. Many buyers are laying down supplies of iron against their needs over the remainder of the year.

MIDLANDS—It is possible for users of high-phosphorus iron to buy in excess of their immediate requirements, so that useful stocks are being accumulated at many works. Such a measure is not possible for low-phosphorus and hematite irons, which are still in short supply. Heavy engineering concerns are the chief users of these irons, and many are having to make use of a certain proportion of high-phosphorus iron, refined iron or scrap in their mixtures. In this way iron is being distributed fairly, but preference is, of course, given to the heavy engineering section, which is operating on contracts for Government departments. The situation among the makers of light castings shows no sign of improving, and few works are able to report satisfactory order-books. Consequently, consumption of iron is not very brisk, although the opportunity is usually being taken to keep stocks in excess of early needs.

SCOTLAND—It has not yet been possible to obviate delays in the delivery of pig-iron at all times, but priority consumers are not permitted to be inconvenienced. This especially applies to marine and other heavy engineering foundries, whose books are filled with Government specifications. Conditions among light-castings makers, however, are very dull; a few have been able to adapt their outputs to cope with work of national importance, but, generally speaking, nothing much in the way of Government work has so far been handed out to this trade. Ample tonnages of high-phosphorus iron are coming forward, and small stocks have been set up at many consuming points.

Coke

Ovens are experiencing no difficulty in meeting all the demands of users of foundry coke, despite the fact that substantial orders are being placed, both for current needs and stocking purposes. This is all the more satisfactory, as it enables consumers to maintain a reserve of fuel which might well prove of inestimable value in the winter months. For delivery to Birmingham and Black Country stations, the current quotation for Durham best foundry coke is 62s. 9d. per ton.

Steel

Although new business in ordinary qualities of steel is still rather quiet, it is not possible to secure any more easily supplies for purposes other than those connected with the war effort. Rolling mill programmes in many cases are less extensive, but it is certain that much of the falling away in new business is of a seasonal character. The feature of the steel industry for months past has been the ever-growing pressure for alloy as distinct from carbon steels, and further expansion still is anticipated, as alloy steel is urgently needed by the munitions and other works whose activities are so closely wrapped up with the war effort. It is certain that the call for alloy steel will make it imperative to enlarge production, and the industry has for some time past been making itself fully conversant with the needs of the Government in this respect.

Scrap

More strenuous efforts in the collection and sorting of scrap have had very favourable repercussions on the supply position, and larger tonnages are now being despatched, particularly to the steel-works, from which the strongest demand emanates. While the improvement has been appreciable, there remains urgent need to expedite operations in the scrap market. More attention has lately been paid to demolition scrap, with satisfactory results, while the domestic collection campaign has also contributed materially to the general improvement.

Metals

COPPER—Supplies of copper continue to be largely distributed among industries operating on war contracts, and there is little likelihood of any expansion being made in deliveries to other users. It is believed that current allocations to priority consumers are fully adequate, but the Control are not permitting extravagant consumption of the metal in any direction. Copper quotations are controlled both here and in the United States, where the price of scrap copper has also been stabilised. Very substantial tonnages of copper are being used in the American defence programme, and further economies in ordinary domestic consumption may have to be introduced. It may be difficult for the United States to despatch copper to the U.S.S.R., and it is not thought that any has so far been incorporated in the shipments of war materials which have been made to Russia. United States deliveries of copper in July created a record, the total being 143,089 short tons. Thus, it is not surprising that blister stocks were 4,009 tons lower on the month, while stocks of refined metal fell by 23,780 tons.

TIN—While only moderate business has been done on the London Metal Exchange of late, there has been a resumption of open market sales on forward account by smelters. Supplies of tin for September delivery in the United States are rather tight, and demand for early delivery there is brisk. The considerable quantity of tin which is expected to be shipped from the Straits to the Soviet Union will, it is understood, be partly negotiated by dealers in Straits tin in London.

Replies to the recommendations of the representatives on the International Tin Committee have now been received from Thailand, the Belgian Congo and the Netherlands East Indies. Senor Patino, representing Bolivian interests, is expected to reach this country from New York shortly, by which time the replies of the Malayan and Nigerian Governments are also expected to have been received, after which a meeting of the Committee will doubtless be held. The United States will not be represented, as the U.S. Government has not found it possible to accede to the requests for representatives to be sent to the Committee's meetings.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £256 10s. to £257; Friday, £256 5s. to £256 10s.; Monday, £256 5s. to £256 10s.; Tuesday, £256 to £256 5s.; Wednesday, £256 10s. to £257.

Three Months—Thursday, £259 10s. to £260; Friday, £259 15s. to £260; Monday, £259 15s. to £260; Tuesday, £259 15s. to £260; Wednesday, £259 15s. to £260.

SPELTER—Keen pressure for supplies of spelter is being made by the brass, die-casting and zinc rolling industries, which are closely associated with war materials production. It is necessary for the Control to import American metal, but in the United States, too, there is a strong demand for zinc, so that it may not be easy for shipments to be made to Russia, which, it is presumed, will have to seek supplies outside her own territory in order to feed her war machine.

LEAD—While the authorities are restricting domestic consumption of lead to some extent, the need for economy is less acute with regard to this metal than in others. All urgent requirements are readily satisfied, and there is a surplus which is being carefully allocated among less important users. It is not now expected that the recent purchases of Canadian lead by the American Metals Reserve Company will in any way imperil deliveries to Great Britain, although substantial quantities of Canadian lead are shipped to this country.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

534,141 TALBOYS MANUFACTURING COMPANY, LIMITED, and LAWRENCE, E. G. Process for coating articles with tin and other fusible metals.

534,115 OHIO CRANKSHAFT COMPANY. Apparatus for the electric heat-treatment of articles.

534,122 RHODES, C. P. Presses for drawing sheet metal.

534,130 CURRAN & COMPANY, LIMITED, E., and KITSON, J. H. Turntables for carrying casting-moulds.

534,131 MALLORY METALLURGICAL PRODUCTS, LIMITED, and HUNT, L. B. Hard metal compositions.

534,171 THORNTON, A. A. (Cleveland Graphite Bronze Company). Method of and apparatus for making bimetallic or composite strip.

534,174 LINDE AIR PRODUCTS COMPANY. Apparatus for thermally removing metal from or otherwise conditioning the surfaces of metal bodies.

534,184 BRAIME, LIMITED, T. F., & J. H., and BRAIME, T. F. Method of, and means for, forming built-up welded rings.

534,268 VANADIUM CORPORATION OF AMERICA. Production of cast iron.

534,276 SURFACE COMBUSTION CORPORATION. Heat-treatment of metals.

534,323 EASTERN CLAY PRODUCTS, INC. Foundry compositions.